

## Bacterial and Clinical Criteria Relating to the Outcome of Patients Undergoing *in situ* Replacement of Infected Abdominal Aortic Grafts

F. Speziale, L. Rizzo, E. Sbarigia, M. F. Giannoni, M. Massucci, C. Maraglino, E. Santoro and P. Fiorani\*

Department of Vascular Surgery, University of Rome "La Sapienza", 00161 Rome, Italy

**Objectives:** In a retrospective non-randomised study we assessed the outcome after *in situ* replacement of infected knitted Dacron abdominal aortic grafts in patients without septicaemia or retroperitoneal abscesses. We also assessed whether the specific bacterial infection influenced outcome.

**Materials and methods:** Over the 5 years studied, 18 patients (9 with perigraft infection and 9 with aortoenteric erosion) underwent *in situ* replacement of aortofemoral grafts. All patients were haemodynamically stable, none required emergency treatment. Preoperative assessment included CT, MRI, leukocyte-labelled scintigraphy, and bacterial cultures whenever possible. Infected grafts were totally excised and replaced *in situ* with standard PTFE prostheses. Bacterial diagnosis included intraoperative Gram-staining and postoperative graft cultures. None of the patients had retroperitoneal collections or proximal anastomotic dehiscence. All patients had 6 week intravenous antibiotic therapy.

**Results:** One patient died of myocardial infarction, and another of haemorrhagic shock from proximal anastomotic dehiscence, accounting for a graft-related mortality of 6%. Dehiscence resulted from a polymicrobial infection. Mean 37 month surveillance showed no amputations and no graft-related infections.

**Conclusions:** In clinically and bacteriologically selected patients, total *in situ* replacement of infected abdominal aortic grafts offers an excellent outcome.

**Key Words:** Aortic graft; Graft sepsis; *In situ* replacement.

### Introduction

Infected abdominal aortic grafts rank among the most severe complications of vascular surgery, with high mortality and morbidity.<sup>1,2</sup> The conventional procedure for their management involves excision of the graft, aortic ligation and restoration of lower limb blood flow by extra-anatomic bypass grafting. An alternative and more conservative approach requires total excision of the graft and placement of a new graft in the same location. Reviewing the published results of surgical treatment for infected prostheses in 1983, Bunt<sup>3</sup> reported that the mortality rates for the two operative procedures differed significantly (38% for excision followed by aortic ligation vs. 56% for *in situ* replacement). During recent years, graft excision and aortic ligation has therefore gained acceptance as the treatment of choice for infected abdominal aortic

grafts. Recently, more effective correction of risk factors, advances in antibiotic therapy, and, possibly, the shorter operating time achieved by completing the extra-anatomic revascularisation a few days before excision of the graft, have considerably improved results, so that mortality now ranges from 14 to 29%, and the incidence of amputation ranges from 13 to 29%.<sup>4-9</sup>

Despite the potential risk of reinfection by placing the new graft into an infected operating field, several investigators have repropounded *in situ* graft replacement for treating aortoenteric fistulae<sup>10-13</sup> and perigraft infection.<sup>14</sup> In establishing the clinical criteria for *in situ* replacement, published case series agree that this operation has a greater likelihood of success in patients with localised graft infections (absence of septicaemia or extensive purulent retroperitoneal collections), i.e. low-grade infections.<sup>12</sup> In contrast, the bacteriological criteria underlying the indications for *in situ* replacement remain less clear, mainly because few study protocols in published series have included

\*Please address all correspondence to: Dr. P. Fiorani, Department of Vascular Surgery, University of Rome "La Sapienza", Policlinico "Umberto I", 00161 Rome, Italy.

preoperative, intraoperative and postoperative bacteriological tests. Lack of outcome data has so far precluded clear indications for *in situ* graft replacement in patients with Gram-negative or Gram-negative-Gram-positive infections. But ample experimental and clinical data suggest that *Pseudomonas* infection is an absolute contraindication.<sup>15</sup>

In this study we retrospectively assessed outcome in a series of 18 patients, all of whom had low-grade infections, treated by *in situ* prosthetic-graft replacement for infected abdominal aortic grafts.

### Materials and Methods

Between December 1989 and February 1995, 20 patients were referred to the Vascular Surgery Unit at the University of Rome "La Sapienza", Italy, for treatment of infected synthetic abdominal aortic grafts and 18 underwent *in situ* replacement. Two patients were excluded from the management protocol because they had more severe clinical disease (positive blood cultures, septic lower-limb emboli with retroperitoneal collection). Graft infections were diagnosed at a mean 46 months (range 6 months – 11 years) after the original aortic reconstruction. Of the 18 patients (17 men and 1 woman, mean age 64.7 years; range 31 – 77 years), eight (44%) had originally undergone surgery for occlusive arterial disease (5 at Leriche stage II and 3 at stage III) and 10 (56%) for infrarenal aortic aneurysms, one a ruptured aneurysm. All repairs had been done under perioperative antibiotic coverage, with knitted Dacron grafts. Twelve patients had originally received aortomonofemoral or aortobifemoral bypass grafts; five had aorto-aortic grafts and one an aortobiiliac graft. All patients had had an uncomplicated postoperative course.

Clinical examination showed that all patients were haemodynamically stable, none of them required emergency treatment. The most frequent symptom (12 patients, 67%) was intermittent fever of at least 30 days duration, seven patients (39%) reported gastrointestinal bleeding: four of them with occult faecal blood, and three with a single episode of melaena with an average onset 20 days before admittance. Six patients (33%) had the classic combination of fever and gastrointestinal bleeding; and two also complained of severe weight loss (> 6 kg) during the past 3 months. Eleven patients (61%) also had groin symptoms, caused in five cases (42%) by cutaneous sinus tracts, in three (25%) by abscesses, and in three (25%) by false anastomotic aneurysms, demonstrated by ultrasound. (Table 1).

**Table 1. Incidence of symptoms in 18 patients undergoing *in situ* replacement of infected abdominal aortic grafts.**

Symptoms	No. of patients (%)
Fever	12 (67)
Gastrointestinal bleeding	7 (39)
melaena	3
occult faecal blood	4
Fever+gastrointestinal bleeding	6 (33)
Groin sinus tract	5 (42)
Groin abscess	3 (25)
Groin false aneurysm	3 (25)
Weight loss (> 6 kg)	2 (11)

Apart from abnormal erythrocyte sedimentation rates in 15 patients (84%) and abnormal white-cell counts in 5 (28%) all patients had biochemical test findings, (including red cell count, partial thromboplastin time, prothrombin time, fibrinogen), within normal ranges. Arteriograms were obtained in all patients, for planning surgical treatment. CT scans, obtained in all subjects at admittance showed that 13 patients (72%) had evidence of periprosthetic infection (gas bubbles, periprosthetic inflammatory reactions) but none of them had gross retroperitoneal collections. MRI, obtained in eight cases, showed that six patients (75%) had evident signs of prosthetic graft infection (medium weight intensity on T<sub>1</sub> images and high intensity on T<sub>2</sub> images); in all 18 patients 99m-Tc scans revealed a pathologic accumulation of leukocytes along the entire graft (Table 2). The seven patients who had previous gastrointestinal bleeding underwent gastroduodenoscopy as the first diagnostic intervention (Table 2). Six of the seven (86%) had aortoenteric erosions in the 3rd to 4th portion of the duodenum. Because we found aortoenteric erosions at operation in two patients without previous symptoms of gastrointestinal bleeding endoscopy became a routine diagnostic procedure in our patients with documented graft infection.

Blood samples, taken from arm veins, were cultured twice; in febrile patients they were cultured at peak fever. Despite 3–4 weeks incubation, blood cultures invariably yielded negative results. In the eight patients who had groin sinus tracts or abscesses, preoperative removal of samples for bacterial culture

**Table 2. Preoperative diagnostic sensitivity of imaging procedures in patients with infected abdominal aortic grafts.**

	No. of patients	No. correctly diagnosed (%)
CT scan	18	13 (72)
MRI scan	8	6 (75)
99m-Tc scintigraphy	18	18 (100)
Gastroduodenoscopy	7	6 (86)

allowed the responsible agent to be isolated. Most infections (7 patients) were caused by *Staphylococcus epidermidis*, and one by *Staphylococcus aureus* later confirmed by bacterial culture of material from the excised graft. All eight positive patients received preoperative specific antibiotic therapy (cephalosporins, ciprofloxacin, imipenem) lasting on average 16 days (range 8–25 days). The remaining 10 patients received broad-spectrum antibiotic therapy (cephalosporins and metronidazole or imipenem). In all cases antibiotic therapy resolved the fever and slightly reduced the erythrocyte sedimentation rate. In four cases a repeat 99m-Tc scan, obtained 7 days later, showed an unchanged leukocyte accumulation.

#### Perioperative management

The basic operative procedure comprised excision of the prosthetic graft and immediate *in situ* replacement with a standard polytetrafluorethylene (PTFE) graft. An infrarenal clamp was used in 88% and a suprarenal clamp in 12%. Nine patients had aortoenteric erosions. In these patients, before vascular intervention, the duodenal lesion was repaired, in six cases by simple suture and in three cases by a resection of a third part of the duodenum and end-to-end intestinal anastomosis.

None of the infected prosthetic grafts adhered closely to the surrounding tissues, none had unduly large purulent collections, and none of the proximal aortic anastomoses showed signs of suture-line dehiscence. Intraoperative microscopic examination of samples from periprosthetic tissues confirmed aspecific infection but provided few guidelines to the operative strategy. Twelve specimens contained leukocytes, four showed small numbers of Gram-positive cocci and two had Gram-negative bacilli. Although the bacteriologic findings obtained from examination of arterial-wall fragments, periprosthetic tissue and tissue from various parts of the excised graft eventually provided more specific findings, these results did not become available until some days after surgery.

Before *in situ* placement of the new graft, surrounding necrotic tissues and sinus tracts were debrided as thoroughly as possible before the field was washed repeatedly with an antiseptic solution containing 2% povidine-iodine. In all cases the operation concluded with *in situ* replacement of the excised graft with a new PTFE prosthesis, by means of an end-to-end anastomosis. To circumvent inguinal sepsis we did two aortofemoral transobturator bypasses and in one patient we implanted an autologous inguinal prosthe-

sis constructed from endarterectomised superficial femoral artery. In patients with aortoenteric erosions, whenever possible we isolated the new prosthesis from the duodenum by an omental wrap. All patients had retroperitoneal drainage tubes; patients with aortofemoral bypass also had inguinal drainage. While fluid secretion continued, samples were obtained for bacterial cultures to monitor the efficacy of antibiotic therapy. Drainage liquid proved bactericidal at up to 1/8 dilution. In addition to preoperative antibiotic prophylaxis, all patients received intravenous specific antibiotic therapy for 6 weeks postoperatively followed by a 2 week course of oral therapy. The efficacy of systemic antibiotic therapy was monitored with a serumcidal titre test (Schlichter test).<sup>16</sup>

#### Results

Two of the 18 patients who underwent *in situ* replacement of aortic abdominal prosthetic grafts died during the postoperative course: the first on the 2nd postoperative day after a myocardial infarction and the other, a patient who had an aortoenteric erosion, on the 19th postoperative day because of haemorrhagic shock. Autopsy revealed dehiscence of the proximal anastomosis.

None of the remaining 16 operations resulted in perioperative deaths, none of the prostheses thrombosed and no amputations were needed.

Cultures of material removed from the eight patients with sinus tracts and inguinal abscesses confirmed the preoperative bacteriologic findings. In the other 10 patients, the following bacteria were isolated: *Staphylococcus epidermidis* associated with *Escherichia coli* in two cases; *Staphylococcus aureus* in five patients with coexisting *Escherichia coli* in two; one patient had *Serratia marcescens* and another had a polymicrobial association (*Proteus mirabilis*, *Bacteroides fragilis* and *Escherichia coli*). One patient had negative cultures (Table 3).

Table 3. Microorganisms cultured from patients with infected abdominal aortic grafts.

Bacterial organisms	No. of patients (%)
<i>Staphylococcus epidermidis</i> (alone)	7 (39)
<i>Staphylococcus aureus</i> (alone)	4 (22)
<i>Staphylococcus epidermidis</i> + <i>Escherichia coli</i>	2 (11)
<i>Staphylococcus aureus</i> + <i>Escherichia coli</i>	2 (11)
<i>Serratia marcescens</i>	1 (6)
<i>Escherichia coli</i> + <i>Proteus mirabilis</i> + <i>Bacteroides fragilis</i>	1 (6)
No growth	1 (6)

Table 4. Characteristics of patients with Perigraft infection.

Patient	Original graft	Symptoms	Graft cultures	Surgical treatment	Outcome (follow-up)
1	Aortofemoral	Groin abscess	<i>Staph. EPI</i>	PTFE <i>in situ</i> replacement	Uneventful (40 months)
2	Aortobifemoral	Groin false aneurysm	<i>Staph. EPI</i>	PTFE <i>in situ</i> replacement	Uneventful (43 months)
3	Aortobifemoral	Groin sinus	<i>Staph. EPI</i>	PTFE <i>in situ</i> replacement	Uneventful (44 months)
4	Aortobifemoral	Groin abscess, fever	<i>Staph. EPI</i>	PTFE <i>in situ</i> replacement	Uneventful (39 months)
5	Aortoaortic	Fever	<i>Staph. aureus</i>	PTFE <i>in situ</i> replacement	Uneventful (42 months)
6	Aortobifemoral	Groin false aneurysm	<i>Staph. EPI</i>	PTFE <i>in situ</i> replacement	Uneventful (36 months)
7	Aortobifemoral	Groin false aneurysm	No growth	PTFE <i>in situ</i> replacement	Uneventful (39 months)
8	Aortobifemoral	Groin abscess, fever	<i>Staph. EPI</i>	PTFE <i>in situ</i> replacement	Uneventful (12 months)
9	Aortobifemoral	Groin sinus, fever	<i>Staph. EPI</i>	PTFE <i>in situ</i> replacement	Uneventful (44 months)

*Staph. EPI*: Coagulase-negative *Staphylococcus epidermidis*

Postoperative follow-up studies included 3 monthly clinical assessments, a 6 monthly CT and 99m-Tc scan for the first year and yearly thereafter. During a mean follow-up of 37 months (range 8–59 months) none of the 16 patients who survived had infective graft-related complications. Two patients needed thrombectomy for occlusion of a prostheses, one patient at 4 months and the other at 12 months after surgery. One patient died of lung cancer 44 months after *in situ* replacement with no evidence of graft complications.

### Discussion

The patients undergoing *in situ* replacement of infected abdominal aortic grafts reviewed in this retrospective study reflect the clinical diversity typically seen in a specialised vascular surgical department. Over the years, numerous proposals have been made for the ideal treatment of aortic grafts infections. Some reports have described occasional successes

with conservative management consisting of drainage of the pus (with ultrasound- or CT-guided needle aspiration) followed by antibiotic therapy directed against the specific responsible micro-organism.<sup>17</sup> An alternative conservative approach requiring minimal surgery with aggressive, long-term antibiotic treatment led to a successful outcome in most of the patients treated.<sup>18</sup> As a temporary procedure before definitive treatment, others<sup>19</sup> have suggested cross-femoral autologous grafts in aortofemoral graft infections. But the most widely accepted surgical procedure is excision of the infected graft, ligation of the aorta and extra-anatomic revascularisation of the lower limbs. Although this treatment has undoubtedly improved results room for further improvement remains. However, these procedures are technically complex, they entail lengthy operating times, and usually have to be done as emergencies, often in patients in compromised general conditions.<sup>7,13,20</sup> They also have a high risk of late complications including dehiscence of the aortic ligation or formation of false aortic aneurysms.<sup>6,21</sup> Extra-anatomic

Table 5. Characteristics of patients with aortoenteric erosions.

Patient	Original graft	Symptoms	Graft cultures	Surgical treatment	Outcome (follow-up)
1	Aortoaortic	GI bleeding, fever	<i>Staph. aureus</i>	PTFE <i>in situ</i> replacement	Died of lung cancer (44 months postop.)
2	Aortobifemoral	GI bleeding, groin sinus	<i>Staph. EPI</i> + <i>E. coli</i>	PTFE <i>in situ</i> replacement +TO bypass	Uneventful (27 months)
3	Aortobifemoral	Groin sinus, fever	<i>Staph. EPI</i> + <i>E. coli</i>	PTFE <i>in situ</i> replacement	Died 2nd postop. day (myocardial infarction)
4	Aortofemoral	GI bleeding, fever	<i>Staph. aureus</i>	PTFE <i>in situ</i> replacement +Endar. SFA	Uneventful (59 months)
5	Aortobifemoral	GI bleeding, fever	<i>Serratia marcescens</i>	PTFE <i>in situ</i> replacement	Uneventful (33 months)
6	Aortobifemoral	GI bleeding, groin sinus, fever	<i>Staph. aureus</i> + <i>E. coli</i>	PTFE <i>in situ</i> replacement +TO bypass	Uneventful (32 months)
7	Aortoaortic	GI bleeding, fever	<i>Staph. aureus</i> + <i>E. coli</i>	PTFE <i>in situ</i> replacement	Uneventful (47 months)
8	Aortoaortic	GI bleeding, fever	<i>Pr. mirabilis</i>	PTFE <i>in situ</i> replacement	Died 19th postop. day (haemorrhagic shock)
9	Aortoaortic	Fever	<i>Bact. fragilis</i> , <i>E. coli</i> <i>Staph. aureus</i>	PTFE <i>in situ</i> replacement	Uneventful (8 months)

GI: gastrointestinal; *Staph. EPI*: Coagulase-negative.

TO bypass: Trans-obturator bypass.

Endar. SFA: Endarterectomised superficial femoral artery.

*Pr. mirabilis*: *Proteus mirabilis*; *Bact. fragilis*: *Bacteroides fragilis*.

revascularisation itself also carries a risk of complications related to the prosthetic implant (including thrombosis, infection, and embolisation). Reaching reported rates as high as 40% of these complications often lead to loss of limbs.<sup>22,23</sup>

Encouraged by the positive results obtained in patients operable only by *in situ* graft replacement (for example those needing graft reconstruction for suprarenal or mycotic aneurysms),<sup>24,25</sup> in 1987 Vollmar *et al.*<sup>10</sup> and Walker *et al.*<sup>11</sup> repropounded this more conservative technique for treating aorto-enteric fistulae. Comparing these two procedures, Vollmar *et al.* reported that *in situ* replacement yielded better results (26%) than the conventional procedure (52%). In the same year, Walker *et al.* reported a survival rate of 80% in a case series of 23 patients with aortoenteric fistulae treated by *in situ* replacement of the infected graft. They underlined the importance of the significant association between severe sepsis and death. The mortality rate reached 60% in patients with retroperitoneal abscesses yet only 22% in patients with no pus or only smaller collections. In a retrospective review published in 1991 and referring to 18 patients with double-velour Dacron infected grafts replaced with grafts of the same material, Jacobs *et al.*<sup>12</sup> noted that mortality rates and graft reinfection related strictly to the grade of infection. Patients with severe infection had a mortality rate of 83% and a reinfection rate of 100%; whereas patients with low-grade infection had a mortality of nil and only one patient had graft reinfection. Describing a case series of 11 patients who had aortic infection in various anatomic locations (mycotic aneurysms and secondary aortoenteric fistulae) treated by graft replacement *in situ*, and a mean 5-year follow-up, Robinson *et al.*<sup>13</sup> reported a survival rate of 100%. They also suggested that antibiotic therapy should be continued for at least 6 weeks and concurred with others<sup>11,12</sup> in concluding that infected abdominal grafts should be treated by *in situ* graft replacement only if sepsis is localised to the aorta, without overt retroperitoneal collections. In a later study addressed to the indications for *in situ* graft replacement, Bandyk *et al.*<sup>14</sup> extended the criteria from clinical to bacteriological. Reporting a series of 15 patients with aortofemoral graft infections and a mean follow up of 21 months they concluded that *in situ* replacement—even if limited to replacement of a branch of the graft—was indicated only for patients with coagulase-negative *Staphylococcus epidermididis* infections. Other reports later described *in situ* graft replacements in patients with infections caused by micro-organisms other than coagulase-negative *Staphylococcus epidermididis*, including *Staphylococcus aureus* and *Escherichia coli*. Torsello *et al.*<sup>26</sup> have reported the

results obtained in three patients with *Staphylococcus aureus* infections in whom other revascularisation methods were deemed unfeasible and who received *in situ* replacement with rifampicin-impregnated prostheses. Calligaro *et al.*<sup>15</sup> described a series of 42 patients with graft infections, 33 identified in bacteriologic cultures as Gram-positive and 22 as Gram-negative. They concluded that graft infections caused by Gram-negative and Gram-positive micro-organisms other than *Pseudomonas* could be safely treated by *in situ* replacement provided that periprosthetic necrotic tissues were thoroughly debrided and patients received prolonged antibiotic therapy. Despite being responsible for less than 10% of graft infections, *Pseudomonas* is an unusually aggressive micro-organism, which causes dehiscence of the suture lines even in grafts constructed from autologous material.<sup>15,27</sup> The published findings indicate that the feasibility of *in situ* replacement rests on two guiding principles, namely the clinical criteria and the bacteriological indications dictated by the specific pathogenic agent. Whereas the majority seem to agree that the clinical criteria preclude *in situ* replacement in patients with systemic signs and localised foci of severe infection, the bacteriological criteria for this option remain debatable. All agents, except coagulase-negative *Staphylococcus epidermididis*, remain under discussion.

An evident problem with preoperative bacteriological testing is that cultures, for identifying the responsible pathogenic agent, can often be obtained only in patients with infected sinus tracts or groin abscesses. Intraoperative Gram staining of the infected excised specimen is equally unsatisfactory because it merely identifies the presence of leukocytes, cocci or bacilli without specifying the species. Because the definitive results of bacteriologic identification in cultures from the excised specimen rarely become available until days after the operation, the indications for *in situ* graft replacement often depend on clinical criteria alone, together with an absence of extensive retroperitoneal collections on CT scanning. In our patients the causative agent was diagnosed either by preoperative (8 cases) or postoperative cultures (10 cases). Our follow-up data suggests that the type of micro-organism did not influence the surgical outcome. However, one patient, who had an aortoenteric erosion, died 19 days after surgery because of haemorrhagic shock secondary to dehiscence of the proximal anastomosis. In this case, because intraoperative Gram staining showed the presence of leukocytes alone, and because we found no purulent retroperitoneal collections we decided to do an *in situ* graft replacement. This patient's death was probably due to the exceptionally virulent bacterial "cocktail" (*Proteus mirabilis*,

*Bacteroides fragilis* and *Escherichia coli*) isolated from the graft after incubation lasting 14 days. A likely reason for this lengthy incubation was the prolonged preoperative antibiotic therapy of more than 60 days.

From a technical standpoint, even in patients with clinical symptoms limited to the groin, we based our decision to undertake total graft excision less on clinical data and more on 99m-Tc scintigraphic evidence of leukocyte uptake at the proximal anastomosis. This finding was later confirmed by bacteriological cultures. Radical excision of the graft may be one reason why none of our patients had the postoperative infections commonly reported in other series<sup>11,30,31</sup> referring to patients with aortobifemoral bypass and signs of localised groin infection treated by partial resection of the infected branch and *in situ* replacement. Follow-up studies showed that these recurrent postoperative infections of the aortic portion of the original prosthetic graft had an incidence ranging from 9.5 to 15%.

Although the ideal material for *in situ* replacement grafts remains controversial, most vascular surgeons<sup>11-13</sup> use Dacron grafts. Recent papers have described the experimental and clinical use of Dacron prostheses impregnated with rifampicin.<sup>26,32</sup> In 1991 Bahnini *et al.*,<sup>33</sup> described the first case of an infected aortic graft replaced with an aortic prosthesis constructed using cryopreserved aorta from a cadaver. In 1994 these investigators reported a case series of 58 patients with infected aortic grafts treated by this procedure.<sup>34</sup> The immediate results obtained after transplanting the homologous tissue indicated a perioperative mortality of 13.8%, with no major amputations. During long term follow-up (mean 19.6 ± 14.0 months) only one patient died because of reinfection; whereas 24% of the patients had aortic dilation, iliac-bifemoral lesions or other graft-related complications. If the immunologic problems that probably underlie these complications can be solved, these allografts may in future be preferred to synthetic grafts. In 1995, Nevelsteen *et al.*<sup>35</sup> reported autogenous reconstruction with the superficial femoral vein in 12 patients with prosthetic infection after aorto (ilio)femoral grafting. A mean 17 months follow-up showed no reinfections, one occluded graft, and minimal disability from removal of the deep veins.

Since 1989 we have used PTFE grafts because the bacteria that most commonly cause primary graft infections adhere much less easily to PTFE than to Dacron.<sup>36</sup> During the 37 month follow-up no patients had signs compatible with graft reinfection. Our protocol for surveillance of patients with *in situ* replacement of prosthetic grafts consisted of 3 monthly clinical assessments, 6 monthly CT scan and

99m-Tc scan for the first year, and yearly assessments thereafter. We have found 99m-Tc scan a particularly reliable diagnostic technique for assessing graft infection.<sup>37</sup> It has the notable advantage of revealing the earliest signs of bacterial contamination after grafting.<sup>38-40</sup>

In conclusion, although an infected abdominal aortic prostheses still remains a severe event, surgical treatment offers patients better prospects now than in the past. However, the improved surgical outcome remains strictly related to the timeliness of diagnosis and to the grade of clinical severity. In patients with low-grade graft infections *in situ* replacement surgery has an excellent chance of success.

Infections caused by coagulase-negative *Staphylococcus epidermidis* and other bacteria can be successfully treated by *in situ* graft replacement. However, graft infections due to aggressive or mixed bacterial strains still portend an exceedingly poor prognosis.

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